The obscure hemisphere

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The obscure hemisphere: What do stroke clinicians know about right- versus left-hemisphere lesions?

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Abstract

To investigate clinical knowledge of left and right cerebral hemisphere cognitive impairments, we devised a questionnaire asking respondents to ascribe cognitive symptoms to each hemisphere. Stroke physicians (N = 109), but not neuropsychologists (N = 56), ascribed more symptoms to the right hemisphere than to the left, showing a lack of specificity for this side. Physicians may tend to select this side when uncertain, because they (wrongly) assume they know less about the 'obscure' right hemisphere.

Introduction

Lesions to the right side of the brain can cause diverse cognitive impairments, affecting key functions such as attention, awareness and emotional processing. These deficits are not uncommon. Prevalence rates depend upon the timing and method of assessment, but unilateral neglect has been estimated to be present in up to 81% of right hemisphere stroke patients (Buxbaum et al., 2004), anosognosia for hemiplegia (AHP) in up to 77% (Orfei et al., 2007), while flattened affect, or apathy, can affect around 25% of stroke patients (Brodaty, Sachdev, Withall, Altendorf, Valenzuela & Lorentz, 2005; Caeiro, Ferro & Figueira, 2012), and is more common in those with right hemisphere lesions.

While cognitive impairments are thus common following right hemisphere stroke, they may not always be clinically salient. For example, impairments of emotion regulation, such as speech aprosody or reduced emotional responsiveness, may be mistaken for a lack of engagement with rehabilitation tasks. Similarly, unawareness or lack of concern for deficits (anosognosia or anosodiaphoria) may lead patients to under-report their symptoms (Barrett, 2010). They may also be mistaken for a dispositional tendency towards optimism, rather than neurological symptoms in their own right (Damasio, 2008). This could have serious clinical implications, for example physicians may be less confident in diagnosing right hemisphere strokes, especially in patients with milder deficits, and may be slower to give emergency treatments such as thrombolysis (Foerch et al., 2005).

If cognitive problems are not identified, or are misapprehended by stroke physicians and clinical staff, then this could also have implications for patient/professional caregiver relationships. Clinicians have reported treating patients that they perceive as unmotivated differently to those that seem motivated (Maclean, Pound, Wolfe & Rudd, 2002). Furthermore, anosognosia for the symptoms of a stroke, or indifference to them, can be

bewildering and distressing to caregivers (Heilman & Harciarek, 2010), who may need to be increasingly vigilant in ensuring the patient's safety. Any lack of professional support or understanding of cognitive symptoms is likely to increase caregiver burden, as suggested by this advice from the Stroke Association: "Cognitive problems are often missed by doctors and sometimes it can be difficult to get them taken seriously. However, you need to trust that you know your family member or friend better than they do, so don't be afraid to keep pushing to get the support you need" (Stroke Association, 2015, p. 20).

One of the present authors (SRH) presented a talk to the British Association of Stroke Physicians at the 2011 UK Stroke Forum (Glasgow, 29 November – 1 December), highlighting the effects of right hemisphere strokes on cognition. This talk, entitled The Lost Hemisphere, was motivated by his concern that, because of their possible lower salience, right hemisphere cognitive impairments may be less recognised by stroke clinicians than left hemisphere impairments. To investigate this, a questionnaire was devised and distributed to stroke physicians, requiring them to ascribe different cognitive symptoms to either left- or right-sided brain lesions. The same questionnaire was administered to a group of neuropsychologists, in order to estimate a baseline level of recognition accuracy among neuropsychological specialists. It was anticipated that stroke physicians would show higher recognition accuracy for left than for right hemisphere cognitive symptoms. Given that the questionnaire relates to their area of specialist expertise, the neuropsychologists were expected to have higher overall accuracy in recognising cognitive symptoms, and little or no imbalance in correct ascription of symptoms to each hemisphere.

Method

Questionnaire Development

The 'Lateralization Questionnaire' consisted of a list of fourteen lateralized cognitive symptoms, intermingled with six non-lateralized cognitive or physical symptoms. To select suitable symptoms for inclusion, a comprehensive list of cognitive impairments that can result from stroke was compiled from a neuropsychological textbook (Darby & Walsh, 2005). Lateralization was determined initially by our own professional knowledge, and supported by examining key textbooks. For the impairments that were determined as being associated specifically with the left or right hemisphere, literature searches of recent journal publications were conducted using the symptom name and relevant key words, such as 'hemisphere', 'lateralization', 'right' and left', and the resulting lists were hand-searched for relevant articles.

Symptoms were selected to differ in terms of how commonly they are observed, to try to ensure that the questionnaire was neither too difficult nor too easy for respondents, and so avoid floor and ceiling effects. As far as possible, only cognitive impairments having a clear association with either the left or right hemisphere were chosen as targets, however the consistency of lateralization reported in the literature varied considerably across symptoms. Prosopagnosia and auditory verbal agnosia, for example, have both been associated with bilateral lesions as well as lesions to the right and left hemisphere respectively (De Renzi, Perani, Carlesimo, Silveri & Fazio 1994; Poeppel, 2001). Therefore, once the list of symptoms had been compiled, it was sent to six research neuropsychologists, to check whether they agreed with the given hemisphere designation, and also if they considered there to be any difference in overall prevalence between the left and right hemisphere symptoms. No major changes were made as a result of this enquiry, other than the specification of

anosognosia as anosognosia for hemiplegia (AHP), to differentiate it from other types of unawareness.

The final selected list of cognitive symptoms associated with the right hemisphere was prosopagnosia, loss of speech prosody, emotional flatness, anosognosia for hemiplegia, visuospatial neglect, dressing apraxia and topographical agnosia. The final selected list of cognitive symptoms associated with the left hemisphere was aphasia, acalculia, oral apraxia, finger agnosia, auditory verbal agnosia, ideomotor apraxia and agraphia. Four lateralized physical symptoms were used as check questions to ensure that respondents complied with the questionnaire instructions and had the basic understanding that motor, somatosensory and higher visual functions are controlled contralaterally by the brain. For each symptom, respondents were given four tick-box response options: left hemisphere (LH); right hemisphere (RH); Not Applicable (NA), for symptoms that were either non-lateralized or not observed after a stroke; and Don't Know (DK).

Procedure and Respondents

Data from physicians was obtained at the 2012 UK Stroke Forum Conference. One hundred and eighty-six complete questionnaires were returned; respondents were 125 (67%) physicians, 50 (27%) health professionals, two (1%) students, four (2%) other and five (3%) not stated. Of these, 165 (89%) reported working directly with stroke patients.

The questionnaire was also given to a group of professional neuropsychologists at the British Neuropsychological Society 2013 spring meeting and at the 2013 International Neuropsychological Society mid-year meeting. Eighty-nine complete questionnaires were returned; respondents were 21 (24%) clinical neuropsychologists, 25 (28%) research neuropsychologists, 7 (8%) clinical and research neuropsychologists, 24 (27%) students, 10 (11%) other and 2 (2%) not stated. Of these, 48 (54%) reported working directly with stroke

patients.

Twenty-eight questionnaires from the physicians group and 17 questionnaires from the neuropsychologists contained one or more incorrect answers to the check questions and were removed from the analysis, leaving a total of 158 questionnaires from physicians and 72 from neuropsychologists. Finally, in order to ensure that the groups were equivalent in levels of experience, data from respondents listing themselves as health professionals, students or other were also discarded. This left two groups; a participant group of stroke physicians (N = 109), of whom 100 (92%) worked directly with stroke patients, and a comparison group of clinical and research neuropsychologists (N = 56), of whom 29 (52%) worked directly with stroke patients.

Responses from neuropsychologists were obtained to provide a baseline of recognition levels among professionals expected to have specialist knowledge of cognitive impairments after stroke. While the questionnaire did not specify whether those describing themselves as clinical neuropsychologists had obtained qualifications in neuropsychology, all respondents were currently working in neuropsychological settings and all were delegates at specialist neuropsychological conferences.

Results

Responses to the lateralized symptoms by the physicians and neuropsychologists are shown overall in Figure 1.

[Insert Figure 1 about here]

In order to determine whether these responses differed by group and by hemisphere, sensitivity (correct attribution of symptoms to each hemisphere) and specificity (correct rejection of symptoms not associated with the specified hemisphere), as well as overall accuracy were calculated separately for the physicians and neuropsychologists. These measures of performance were calculated for left hemisphere symptoms as follows:

- Accuracy: correct LH responses/(correct LH responses + LH responses to right hemisphere symptoms + all RH, NA and DK responses to left hemisphere symptoms)
- Sensitivity: correct LH responses/(correct LH responses + RH, NA and DK responses to left hemisphere symptoms)
- Specificity: all RH, NA and DK responses to right hemisphere symptoms/(all RH, NA and DK responses to right hemisphere symptoms + LH responses to right hemisphere symptoms)

These measures were calculated in the same way for the right hemisphere symptoms, with LH and RH switched. The mean sensitivity, specificity and accuracy rates for left and right hemisphere symptoms are shown in Table 1.

[Insert Table 1 about here]

Mixed two-way ANOVAs were conducted on each measure, with profession (physician or neuropsychologist) as the between-subjects factor and hemisphere as the within-subjects

factor.

The accuracy data showed a main effect of profession, with the neuropsychologists group being more accurate overall than the physicians group [$F(1,163) = 9.02$, $p = .003$, $\eta^2_p = .05$], reflecting their expertise in cognition. There was no main effect of hemisphere [$F(1,163) = 2.98$, $p = .09$] and no significant interaction [$F(1,163) = 2.35$, $p = .13$].

For sensitivity, there was no main effect of profession; physicians and neuropsychologists did not differ [$F(1,163) = .79$, $p = .38$]. However, there was a significant main effect of hemisphere [$F(1,163) = 7.52$, $p = .007$ $\eta^2_p = .04$], qualified by a significant interaction with group [$F(1,163) = 5.21$, $p = .024$, $\eta^2_p = .03$]. Sensitivity levels were equivalent between hemispheres in the neuropsychologists group (RH = .55, LH = .54), but higher for right- than left-hemisphere symptoms in the physicians group (RH = .59, LH = .45). That is, physicians made more correct hemisphere assignments for right hemisphere symptoms than for left hemisphere symptoms. However, this advantage was offset by a reduced specificity for right hemisphere symptoms, as described below.

Specificity was significantly higher overall for the neuropsychologists group than for the physicians group [$F(1,163) = 54.05$, $p<.001$, $\eta^2_p= .25$], and for the left hemisphere as compared with the right [$F(1,163) = 14.04$, $p < .001$, $\eta^2 = .08$], but these main effects arose in the context of a significant interaction [$F(1,163) = 8.31$, $p = .004$, $\eta^2_p= .05$]. This interaction was complementary to that observed in the sensitivity data: neuropsychologists' specificity was similar between hemispheres (RH = .88, LH = .90), but the physicians' specificity was higher for the left hemisphere than the right (RH = .67, LH = .82). The physician's higher sensitivity for the right hemisphere, and their higher specificity for the left, reflect the same tendency for this group to over-attribute left hemisphere symptoms to the right hemisphere. While the neuropsychologists were far from perfect in their lateralization, this over-

endorsement of the right hemisphere was not evident.

The neuropsychologists group contained many more respondents who did not work directly with stroke patients than the physicians group (27/56 compared with 9/109), and it could therefore be argued that the neuropsychologists do not represent a true picture of expertise in the field of cognitive impairments after stroke. However, re-running the sensitivity, specificity and accuracy analyses on data collected only from those respondents working directly with stroke patients (physicians N = 100, neuropsychologists N = 29) did not change any of the key findings, except for a significant main effect of profession on the sensitivity data [$F(1,127) = 5.26$, $p = .02$, $\eta 2p = .04$]; the neuropsychologists had higher overall sensitivity levels. All of the other main effects and interactions followed the same pattern as the analyses conducted on the full dataset.

Responses to the lateralized symptoms by the physicians and neuropsychologists are shown individually by symptom in Figure 2.

[Insert Figure 2 about here]

To ascertain whether any of the four response options– LH, RH, NA, DK – for each symptom was endorsed at a level higher than chance, the number of positive responses to each of these options was evaluated relative to the total number of valid responses using a binomial test to examine whether that proportion exceeded the 0.25 chance level, with the threshold for significance set to $p< .001$ [$p < .05/(16x4)$, to correct for the total number of comparisons conducted]. Symptoms for which this threshold was exceeded are starred in Figure 2. Instances in which an incorrect response option was endorsed at above chance levels are of particular interest. These occurred only for the physicians group, who showed above chance rates of *incorrect* LH responses to loss of speech prosody and NA responses to emotional flatness, and *incorrect* RH responses to ideomotor apraxia and finger agnosia. The possible

implications of these patterns will be considered in the Discussion.

Discussion

A questionnaire was devised and distributed at professional stroke and neuropsychological conferences, to assess the hypothesis that stroke physicians would be less able to identify symptoms associated with right than left hemisphere lesions. The results seemed, at first appearance, counter to this expectation; the physicians were better able to correctly identify the lateralization of the RH symptoms. However, a different pattern emerged once incorrect endorsements of the opposite hemisphere were taken into account, as the physicians also identified many more left hemisphere symptoms as being associated with the right hemisphere than vice versa. We suggest that this lower specificity for RH impairments may reflect a general tendency among the physicians to endorse the RH for unfamiliar symptoms.

Examination of responses to individual symptoms highlights some possible heuristics used in completing the questionnaire. The only RH impairment endorsed as a left hemisphere symptom above chance levels by the physicians' group was loss of speech prosody, possibly because the physicians readily associated speech problems with LH lesions. This interpretation is supported by the finding that aphasia was almost universally endorsed as a LH symptom. Another symptom with an idiosyncratic pattern was the right hemisphere symptom of 'emotional flatness', the only symptom with above chance rates of 'not applicable' answers. However, as the 'not applicable' response option allowed for both non-lateralised symptoms and non-symptoms, it is unclear whether the physicians did not believe emotional flatness to be associated with the right hemisphere, or whether they did not endorse it as a stroke symptom at all.

There are of course caveats to the methodology employed. First, a lack of consensus about some questionnaire items could reflect a lack of consensus about the predominant hemispheric association for these cognitive impairments. For example, the symptom of

acalculia was attributed to LH lesions by 36% of the neuropsychologists and to RH lesions by 34%, while 18% responded they did not know. Acalculia may present as a LH-associated deficit of calculation, but may also arise as a result of spatial processing deficits, more commonly associated with the right hemisphere, and it is possible that multiple subtypes of acalculia exist, with different hemisphere associations (Basso, Burgio, & Caporali 2000; Rosselli & Ardila, 1989). The high levels of RH and DK endorsements for acalculia may therefore reflect a genuine lack of professional consensus about the lateralisation of this symptom, as much as individual uncertainty among respondents.

It could also be argued that some of the symptoms selected are rarely observed, for example finger agnosia, and arguably have little clinical impact, making it unlikely that they would be recognised. The inclusion of these symptoms, however, was especially useful in highlighting how the groups responded to uncertainty. We had anticipated that, on average, the neuropsychologists would have higher overall accuracy in identifying cognitive symptoms than the stroke clinicians, as the questionnaire related to their specialist field, while the role of the physician is far broader and could be expected to have a greater relative focus on physical symptoms. Although neuropsychologists were indeed more accurate overall than physicians, it should be noted that the neuropsychologists were still only around 50% accurate on average. This may be partly accounted for by the presence of many who did not work directly with stroke patients, or clinical psychologists who only recently specialised in neuropsychology, but is also a likely result of the inclusion of more obscure symptoms.

For the neuropsychologists, imperfect lateralization accuracy was reflected in an increase in ‘don’t know’ responses; this group seemed more reluctant to endorse either the left or right hemisphere for a symptom unless they were reasonably certain of being correct, which is reflected in their higher specificity and overall accuracy scores. Conversely, in the face of uncertainty, the physicians were more inclined to endorse the right hemisphere, leading to

higher sensitivity but lower specificity scores. We suggest that this bias towards the RH, may be accounted for by its supposed 'obscurity' and wide stereotyping as the more mysterious side of the brain (see e.g., Corballis, 2007). This warrants further investigation, particularly to ascertain whether the mythology of the 'mysteriousness' of the RH is sufficiently pervasive to influence clinical opinion, perhaps by probing for knowledge of the characteristics of different cognitive impairments associated with the left and right hemisphere.

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Figures

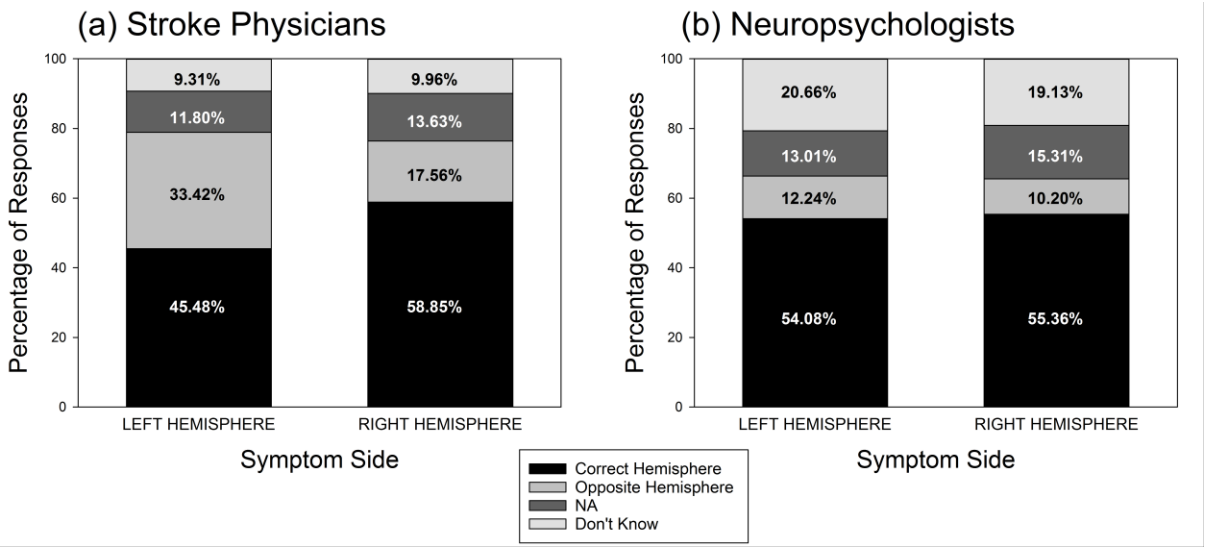

Figure 1: Stroke physicians' and neuropsychologists' overall percentage responses to cognitive symptoms associated with the left and right hemisphere.

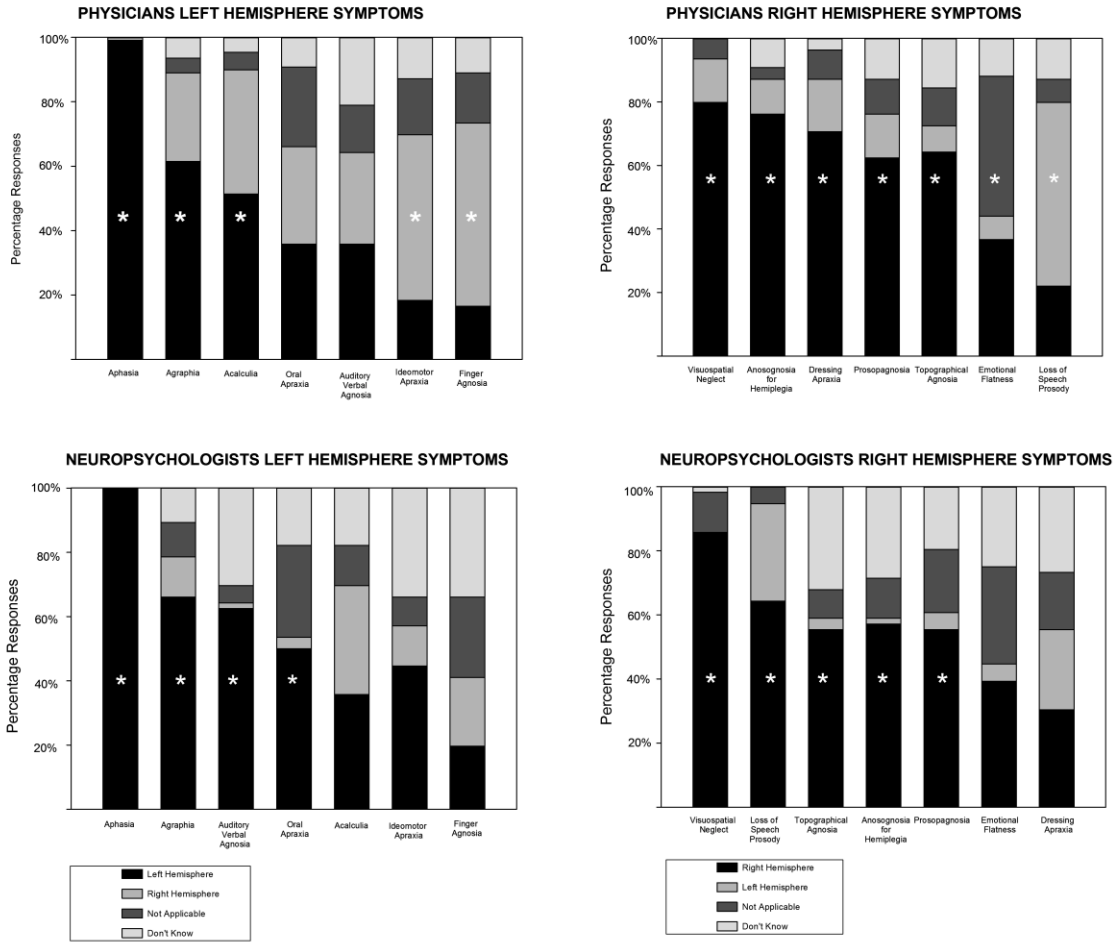

Figure 2. Stroke physicians' and neuropsychologists' percentage responses to individual cognitive symptoms associated with the left and right hemisphere. Stars indicate that the response was given at a significantly higher level than chance for that symptom.

Table 1. Mean (standard deviation) sensitivity, specificity and accuracy of the stroke physicians and neuropsychologists groups' responses to left and right hemisphere cognitive stroke symptoms

Physicians		Left Hemisphere	Right Hemisphere
	Sensitivity	.45 (.23)	.59 (.24)
	Specificity	.82 (.15)	.67 (.26)
	Accuracy	.38 (.19)	.44 (.17)
Neuropsychologists			
		Left Hemisphere	Right Hemisphere
	Sensitivity	.54 (.22)	.55 (.27)
	Specificity	.89 (.11)	.88 (.13)
	Accuracy	.49 (.21)	.50 (.25)